LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

BRITISH MUSEUM (NATURAL HISTORY)

THE

JOHN MURRAY EXPEDITION 1933–34

SCIENTIFIC REPORTS

VOLUME VII, No. 3

CIRRIPEDIA

(ADDITIONAL PART)

BY

H. G. STUBBINGS, M.A., PH.D.(CANTAB.), B.SC.(LOND.)

(Late Scholar of St. Catharine's College, Cambridge)

WITH SIX TEXT-FIGURES

LONDON:
PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM
SOLD BY
B. QUARITCH, LTD., 11 GRAFTON STREET, NEW BOND STREET, LONDON, W. 1; DULAU & CO., LTD., 29 DOVER STREET, LONDON, W. 1; OXFORD UNIVERSITY PRESS, WARWICK SQUARE, LONDON, E.C. 4;
H.M. STATIONERY OFFICE, LONDON, S.W. 1
AND AT
THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, S.W. 7
1940

[All rights reserved]

Price Two Shillings

[Issued 9th March, 1940]

DESIGNED AND
PRINTED
BY
ADLARD & SON
LIMITED

AT
BARTHOLOMEW PRESS
DORKING

Made and printed in Great Britain

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

CIRRIPEDIA

(*ADDITIONAL PART*)

BY

H. G. STUBBINGS, M.A., PH.D.(CANTAB.), B.SC.(LOND.)

(*Late Scholar of St. Catharine's College, Cambridge*)

WITH SIX TEXT-FIGURES.

INTRODUCTION.

THE present report embraces a number of Cirripedia and Cirripede larvæ that have come to light since the publication of the report on the Cirripedia of the John Murray Expedition (Stubbings, 1936). The following species are recorded :

Pagurolepas conchicola g. et sp. nov.
Trilasmis (*Pœcilasma*) *kæmpferi* (Darwin).
T. (*Temnaspis*) *excavatum* (Hoek).
Trilasmis sp.
Verruca (*Rostrato verruca*) *intexta* (Pilsbry).
Balanus (*Balanus*) *trigonus* Darwin.
B. (*Chirona*) *albus* Hoek.
Nauplius I nov.
Nauplius II nov.
Cypris I nov.

Suborder LEPADOMORPHA Pilsbry 1916.

Genus PAGUROLEPAS nov.

DIAGNOSIS.—Capitulum smooth, rigid and slightly asymmetrical : valves five, not covering the whole of the capitulum : cirri greatly reduced with three to four segments only : setæ on appendages long and flexible : first maxilla with very small, weak cutting edge.

I introduce this new genus to receive two specimens of a Lepadomorph barnacle found living inside shells inhabited by hermit crabs. The form of the capitulum and of the appendages is so different from the normal type that it is impossible to assign the specimens to any known genus.

Pagurolepas conchicola sp. nov. (Text-figs. 1–3.)

Occurrence.—Sta. 122, Zanzibar Area, 732 metres; 2 specimens living in shells inhabited by the Pagurid *Parapagurus andersoni* var. *brevimanus* Henderson.

Diagnosis.—Capitulum smooth, rigid, slightly asymmetrical: peduncle annulated: valves five, reduced: terga triangular with strongly concave lower margin and lower angles rounded off: scutum narrow; umbo on occludent margin near basal angle: tergal margin notched for scutal angle of tergum: carina small, leaf-like, poorly calcified, at base of capitulum: cirri small, weak, four-segmented; setæ long and slender, almost as long as rami: no filamentary appendages: caudal appendages unsegmented, equal in length to cirrus VI.

Description.—The capitulum and peduncle are of a pale yellow colour, smooth and hairless. The dimensions of one specimen are as follows:

Length of peduncle	8·0 mm. approx.
,, capitulum	6·0 ,,
Breadth of capitulum	3·0 ,,
Thickness of capitulum	2·5 ,,

The peduncle is annulated. The barnacle is attached to the columella of the Gasteropod shell. The peduncle lies at right-angles to the axis of the columella and consequently takes on a strong curve corresponding to the coil of the shell. On reaching the expanded part of the shell the peduncle is bent so as to bring the capitulum parallel to the shell axis.

The capitulum is plump, nearly as thick as broad. There is no sharply defined carinal border, the carinal surface curving smoothly into the sides of the capitulum. In both specimens the capitulum is slightly asymmetrical, the left side, that nearest to the columella, being slightly narrower than the right. The capitulum is thin but rigid, and rather translucent, a large part of it being uncovered by the valves, five of which are present.

The scutum lies along the occludent margin. It is 3·5 to 4·0 times as long as broad. The umbo is situated on the occludent margin a little above the occludent basal angle; the occludent, inner (carinal) and basal margins of the valve are straight, and the tergal margin is notched to receive the scutal angle of the tergum.

The terga are restricted to the extreme end of the capitulum. Each is approximately triangular, with the angles rounded or squared off. The precise shape of these lower angles seems to be variable: in the two specimens the degree of rounding off varies from a slight rounding of the point, through a broader blunt point to a condition in which a short straight scutal or carinal margin is produced (Text-fig. 1 B). The lower margin of the valve is strongly concave. The umbo lies at the upper angle.

The carina is a small, lanceolate valve lying on the broad carinal surface at the peduncular end of the capitulum. It is rather less than half the length of the capitulum.

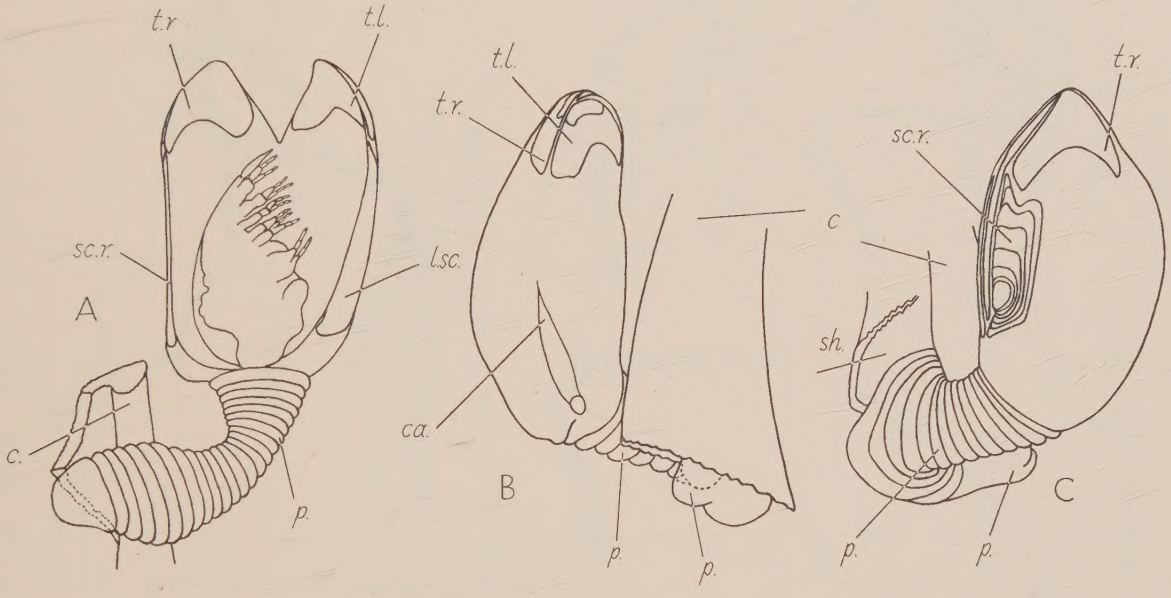
The palpus is a small conical lobe lying close to the first maxilla. It bears setæ along both margins (Text-fig. 2 A).

The mandible (Text-fig. 2 C) is well-developed and has four teeth. The lowest tooth bears two minute teeth on the lower border. The lower lobe is very small and does not project as far as the fourth tooth. It bears one very small tooth and a few small hairs on its anterior edge. There are several very small hairs along the ventral edge of the appendage, and a row along the dorsal border.

The first maxilla (Text-fig. 2 A) differs very considerably from the usual strong, spinose, biting type. The appendage is lobular and bears hairs on the upper and lower borders. The biting edge is exceedingly minute and projects only slightly from the general contour of the appendage. There is one small upper spine on the biting edge, and below it a very small notch containing a minute spinule. Four more minute spinules occur on the lower part of the biting edge.

The second maxilla (Text-fig. 2 B) is broadly conical and similar in shape to the first maxilla. It bears fine hairs along the length of the inner margin and on the outer part of the outer margin. Mingled with these fine hairs are a few longer and stouter ones. These, however, are not rigid spines, but only enlarged flexible hairs.

The cirri are very poorly developed. The pedicel is two-segmented, though the division



TEXT-FIG. 1.—*Pagurolepas conchicola* g. et sp. nov. A, Opened along occludent margin to show the contained animal. B, Carinal view. C, View from right side. *ca.*, carina. *c.*, columella of Gasteropod shell. *l.sc.*, left scutum. *p.*, peduncle. *sc.r.*, right scutum. *sh.*, gasteropod shell. *t.l.*, left tergum. *t.r.*, right tergum. All × 8 approx.

into segments is not always well-marked, *e. g.* in cirri I and VI. All the cirri are somewhat flattened and have nearly straight rami. The rami consist of four segments only. The terminal segment is very minute and bears from two to four curved spines or hooks (Text-fig. 3 C). Cirri II–VI bear dense clusters of setæ on both sides of each ramus. The setæ on the last two segments are very long, being almost as long as the rami. Only a few of the setæ are shown in Text-fig. 3 A–E).

Cirrus I is situated a little apart from the others. The pedicel is greatly flattened and expanded (Text-fig. 3 A) so that the appendage forms a leaf-like plate, from which two short rami arise at the sides of the mouth appendages. The posterior ramus is shorter and more slender than the anterior.

Cirri II–IV have a well-developed pedicel (Text-fig. 3 B). This is not expanded as in Cirrus I, and the second segment is well marked off from the first.

In Cirrus V the pedicel is smaller than in the preceding two cirri.

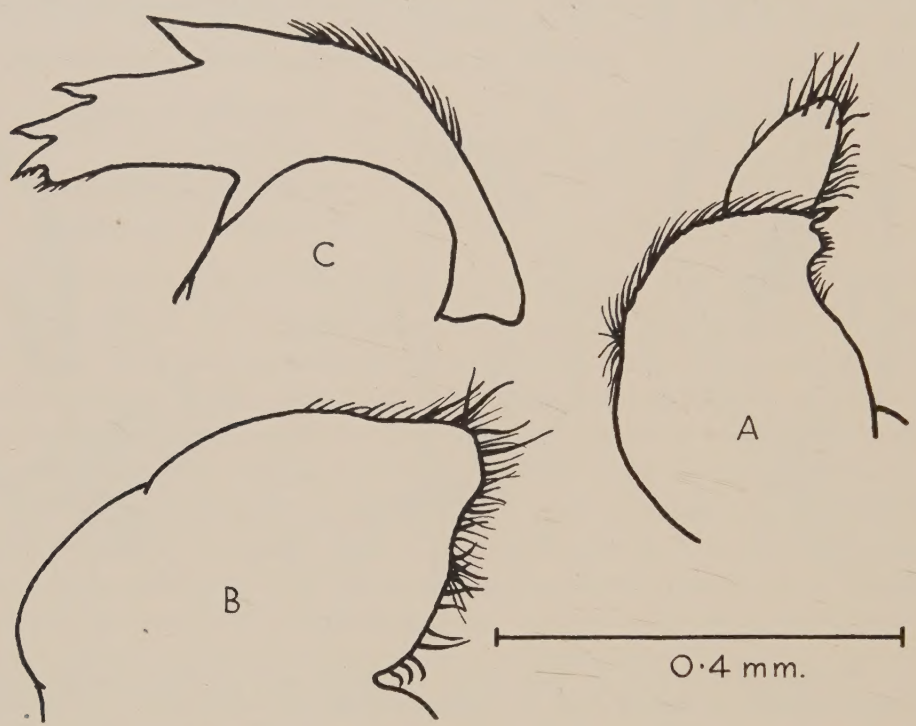
Cirrus VI has a still smaller pedicel. The posterior ramus appears to be three-segmented (Text-fig. 3 D).

There are no filamentary appendages.

The caudal appendages (Text-fig. 3 E) are well-developed. They are one-segmented, leaf-like structures approximately the same length as cirrus VI. They carry a thick tuft of long setæ terminally and a dense row of shorter ones along the anterior margin.

The penis is between two and three times the length of the caudal appendages and is not annulated. It bears a terminal tuft of long hairs and a few others scattered along its ventral surface.

No eggs are present in the mantle cavity of the specimen dissected.

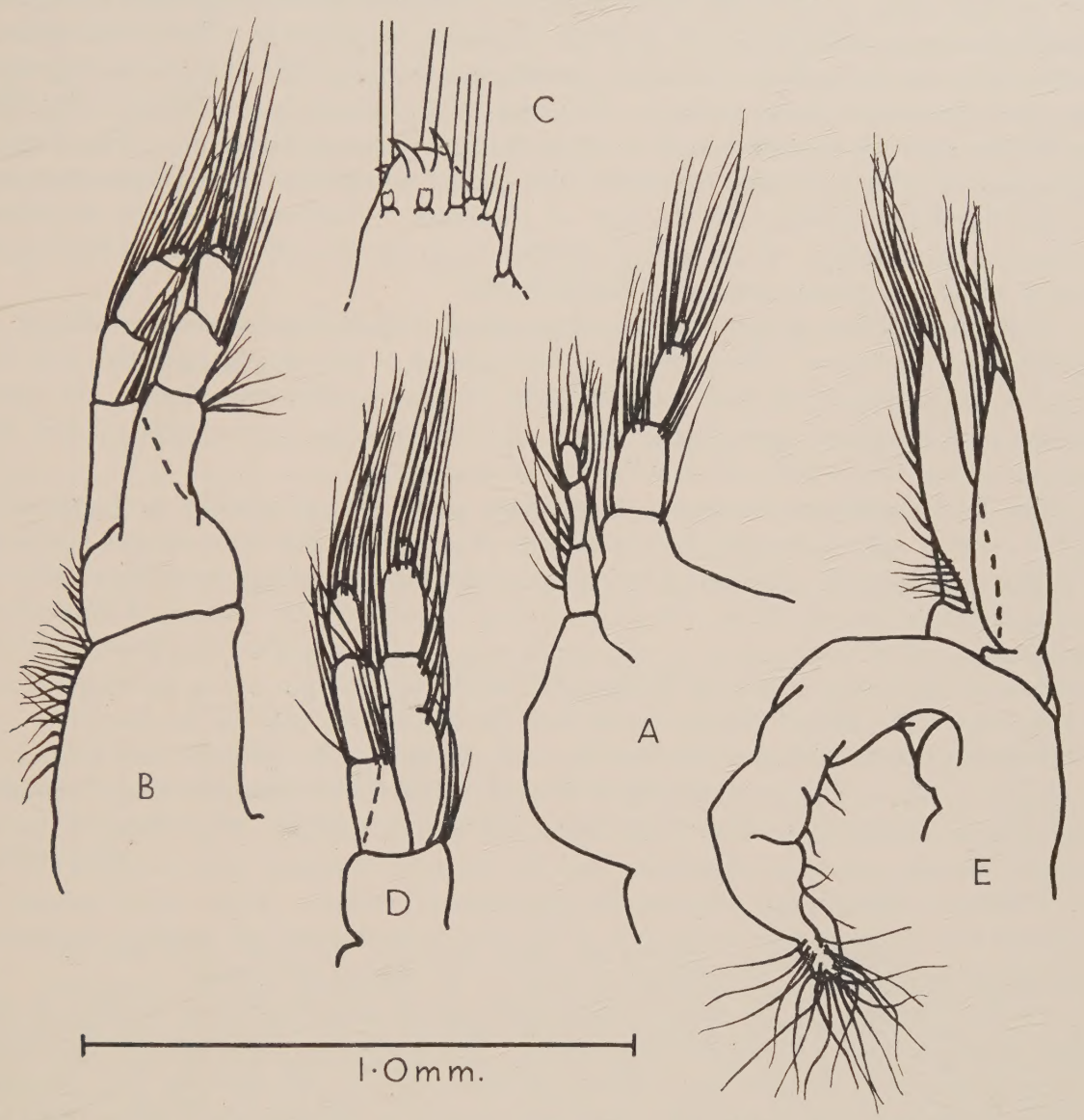


Text-fig. 2. Mouth-parts of *Pagurolepas conchicola* g. et sp. nov. A, Maxilla I and palpus. B, Maxilla II. C, Mandible.

Remarks.—It is noteworthy that the setæ on the appendages are all very weak, stout spines being conspicuous by their absence. Very small spines are present on the first maxilla, which is strongly spinose in most Cirripedia. The only other spine-like structures are the small hooks on the terminal segments of the cirri (Text-fig. 3 C).

The habitat of these barnacles is interesting. They occurred high up in the spire of the Gasteropod shells, far enough back to be above the tail of the Pagurid. Whether they entered by holes in the shell or by the shell mouth it is not possible to say as the shells were destroyed in removing the Pagurids, and whether they were complete or damaged when collected was not recorded. It is possible that the larvæ entered by the shell mouth, being carried in through the branchial chamber of the Pagurid by the current of water, which is continued inwards by the pleopods to aerate the shell cavity (Jackson, 1913, p. 64). This author records (*l. c.*, p. 65) the occurrence in shells inhabited by hermit-crabs of *Anomia ephippium*, which could only have been carried in by some such current.

The food supply of the barnacles is somewhat puzzling. Comparatively few planktonic organisms must find their way into the shell cavity, and the cirri are not adapted as a " cast-net " as in most free-living species. It is possible that they feed on the fine fæcal material excreted into the shell cavity by the Pagurid. Jackson (*l. c.*, p. 65) suggests that



Text-fig. 3.—Cirri and caudal appendages of *Pagurolepas conchicola* g. et sp. nov. A, Cirrus I. B, Cirrus III. C, Tip of segment 4 of outer ramus of Cirrus IV to show the hooked spines, viewed from the outer side. D, Cirrus VI. E, Caudal appendages and penis. All to scale shown, except C, which is greatly enlarged.

the Amphipods found in the apex of shells inhabited by *Eupagurus bernhardus* do this. The long hairs on the cirri may form a sufficiently fine strainer for this material, whereas the normal type of setation is probably too coarse.

It is a little difficult to place *Pagurolepas* in one of the existing families. It bears some resemblance to each of the families Oxynaspidæ (Nilsson-Cantell, 1921), Lepadidæ

(Nilsson-Cantell, 1921) and Trilasmatidæ (Annandale, 1909; Nilsson-Cantell, 1934). It appears to resemble the species of the last family most nearly.

With the Oxynaspidæ it agrees in the number of mandibular teeth, in the absence of filamentary appendages, and in the reduction of the valves, though this has gone further than in *Oxynaspis*. It does not agree, however, in several equally important characters. Thus there are no chitinous spines on either capitulum or peduncle. The scutal umbo is practically at the base of the occludent margin, not in the middle of it, as in *Oxynaspis* spp., and the carinal umbo is basal. The base of the carina is not forked. The first maxilla has scarcely any notch and is not of the type found in *Oxynaspis*. The form of the second maxilla is likewise different. The caudal appendages, though unsegmented, are well-developed compared with those of *Oxynaspis*. *Pagurolepas* cannot, therefore, be placed in this family. In its biology it differs markedly from the species of *Oxynaspis*, most of which are epizoic, usually on Antipatharia.

Pagurolepas differs from the genera of Lepadidæ, *Lepas*, *Conchoderma* and *Alepas*, in the following characters: the presence of four instead of five mandibular teeth and the almost complete absence of pectination on them; the shape of the first maxilla; the entire absence of filamentary appendages, which are well-developed in Lepadidæ; and the presence of leaf-like in place of claw-like caudal appendages.

The Trilasmatidæ are thus left. *Pagurolepas* agrees with this family in the presence of five reduced valves, though there is no sign of a tendency for them to split up as in *Trilasmis* or *Octolasmis*; the strong but not much thickened capitular membrane, without a muscular layer (this character also occurs among Lepadidæ); the absence of filamentary appendages, and of pectinations on the mandibular teeth. It differs somewhat from the members of this family in having unsegmented caudal appendages and in the shape of the first maxilla. The second maxilla agrees with the generalized type for the family.

It is thus to the Trilasmatidæ that the new genus must be referred. As defined by Annandale (1909, as Pœcilasmatinæ) and Nilsson-Cantell (1921, 1934) this family contains three genera, *Trilasmis* (=*Pœcilasma*), *Megalasma* and *Octolasmis*. *Pagurolepas* is distinguished from the species of *Megalasma* and the forms of *Trilasmis* with complete valves, *e. g. Trilasmis* (*Pœcilasma*) *obliquus*, by the reduced valves. From other species of *Trilasmis* it is distinguished by the lack of division of the scutum into separate occludent and carinal plates, and by the absence of spurs at the base of the carina.

In the reduction of the valves *Pagurolepas* agrees with *Octolasmis*, though in the latter reduction takes a rather different course. The tergum is very similar to that found in species such as *O. darwini* and *O. lowei* (see Hiro, 1937, p. 425, text-fig. 16). In most species of *Octolasmis* the carina has a long furca, but in *O. angulata* (Aurivillius, 1894) the valve is reduced, and the furca may be represented by small processes only at the umbonal end. This form of carina approaches very near to that of *Pagurolepas*. The scutum, however, differs markedly from that found in *Octolasmis*. In the latter genus the scutum is usually triradiate or L-shaped. In *O. angulata*, however, a strap-shaped valve is produced by the reduction of the horizontal limb. In this condition the scutum approaches that of *Pagurolepas*, but the valve in the latter is more robust and does not appear to have been formed by reduction from a triradiate or L-shaped scutum.

Pagurolepas thus differs considerably from all the known genera of Trilasmatidæ in the form of the scutum and carina, in the plump roundness of the capitulum, and particularly in the appendages. The mandible, while of the type found in the Trilasmatidæ

and allied families, is distinctly different from that of other species. The first maxilla is even more distinctive. The reduced, rather rudimentary cirri occur nowhere else in the family: they are reminiscent of those found in the Lepadid species *Microlepas diadema* Hoek (1907), though not quite so rudimentary, and in *Gymnolepas pellucida* Aurivillius (1894) (=*Alepas pellucida* (Aurivillius), Pilsbry 1907). Somewhat reduced cirri are found in various members of the Heteralepadidæ, *e. g. Heteralepas* (*Paralepas*) *reticulata* Annandale (1914). It is possible that *Pagurolepas* may represent a stage between the species of Trilasmatidæ with reduced plates and normal cirri and the Heteralepadidæ, in which the plates are absent or very poorly developed and the cirri are often short. The reduction of the cirri in *Pagurolepas*, however, has gone much farther than in most Heteralepadidæ.

Genus TRILASMIS.

Trilasmis (*Pœcilasma*) *kæmpferi* (Darwin).

Pœcilasma kæmpferi, Darwin, 1851, p. 102, pl. ii, fig. 1.
Pœcilasma (*Pœcilasma*) *kæmpferi*, Nilsson-Cantell, 1921, p. 254, text-fig. 46.

Occurrence.—Sta. 157, Maldive Area, 229 metres; 45 specimens attached to a specimen of Homolid crab.

Remarks.—These specimens are all adult except for one small one, in which the primordial plates are visible with only a narrow secondary growth band.

The record is additional to that given in the previous report (Stubbings, 1936, p. 5).

Trilasmis (*Temnaspis*) *excavatum* (Hoek).

Pœcilasma (*Temnaspis*) *excavatum*, Hoek, 1907, p. 10, pl. i, figs. 5–10.

Occurrence.—Sta. 157, Maldive Area, 229 metres; 1 small immature specimen, attached to the same Homolid crab as the above species.

Remarks.—This record is additional to that given in the previous report (Stubbings, 1936, p. 6).

Trilasmis sp.

Occurrence.—Sta. 122, Zanzibar Area, 732 metres; 3 specimens.

Remarks.—These specimens of a recently metamorphosed cirriped were found attached near the peduncles of the specimens of *Pagurolepas conchicola* described above. Five plates are present showing only one growth band. This is very broad on the scutum, which covers most of the capitulum. The terga are small. There is no sign of fission of the scutum so these specimens probably belong to the subgenus *Pœcilasma*. They are too small for further identification.

Suborder VERRUCOMORPHA Pilsbry 1916.

Genus VERRUCA.

Verruca (*Rostratoverruca*) *intexta* Pilsbry.

Verruca intexta, Pilsbry, 1912, p. 292.
Verruca (*Rostratoverruca*) *intexta*, Broch, 1922, p. 298.
Verruca intexta, Nilsson-Cantell, 1927, p. 774, text-fig. 14; 1929, p. 468, text-fig. 3.

Occurrence.—Sta. 106, Zanzibar Area, 183–194 metres; 1 specimen on a shell of *Turris congener* (Smith).*

Remarks.—The single specimen of *Verruca* obtained at this station seems to belong to this species. The basal edges of the walls are not inflected as in *V. nexa* Darwin, which also belongs to this section of *Verruca*. The movable scutum has three ridges articulating with the rostrum. The outer of these latter, that next the fixed scutum, is broad and shows slight traces of division into two ridges. The rostral ridges articulating with the two scuta are poorly developed, three articulating with the movable scutum, and five with the fixed scutum. The specimen resembles most nearly that figured by Nilsson-Cantell (1929, p. 469, text-fig. 3*a*).

Suborder BALANOMORPHA Pilsbry 1916.

Genus BALANUS.

Balanus (*Chirona*) *albus* Hoek.

Balanus albus, Hoek, 1913, p. 185, pl. xvi, figs. 12, 13, pl. xvii, figs. 1–6.
Balanus (*Chirona*) *albus*, Stubbings, 1936, p. 41, text-fig. 18.

Occurrence.—Sta. 106, Zanzibar Area, 183–194 metres; 1 specimen attached to the Gasteropod *Turris congener* (Smith), together with *Verruca intexta*.

Remarks.—This record is additional to those in my earlier report quoted above.

Balanus (*Balanus*) *trigonus* Darwin.

Balanus trigonus, Darwin, 1854, p. 223, pl. iii, figs. 7*a–f*.
Balanus trigonus, Stubbings, 1936, p. 41.

Occurrence.—Sta. 53, South Arabian Coast, 13·5 metres; (i) 4 specimens attached to an orange-brown Tunicate; (ii) 2 clusters of 19 and 9 dry specimens, some of which retain the opercular valves.

Remarks.—The species was recorded in my previous report from Sta. M.B.II (*c*), also on the South Arabian Coast.

CIRRIPEDE LARVÆ.

Nauplius I.

Occurrence.—Sta. 58, South Arabian Coast, surface; 7 specimens.

Description.—These nauplii appear to be in the last or metanauplius stage as paired eyes are present, and the developing cirri can be seen through the wall of the abdominal process. They are dark brown in colour.

The carapace is strongly convex, slightly longer than broad, and without dorsal spines. A pair of short posterior spines, about one-seventh the length of the carapace, is present. The lateral horns are slightly longer than this. The lateral horn glands are large and ovoid. The caudal spine is long, slightly less than half the length of the carapace, and armed with several rows of very small spinules. The abdominal process is armed with

* I am indebted to Mr. R. Winckworth for this specimen and that of *Balanus albus*, also for the identification of the Gasteropod to which they were attached.

two parallel rows of small spines on either side of the mid-ventral line. The first five pairs are of equal size. The sixth pair are twice the size of those anterior to them. Behind the sixth pair lie a pair of much larger spines, and lateral to these a single spine on either side pointing backwards and dorsalwards. All the paired spines on the abdominal process are backwardly curved. The abdominal process reaches nearly to the tip of the caudal spine. It then forks into two large spines, rather more than half as long as the narrow part of the abdominal process. There appear to be no spinules on the abdominal process and spines.

The nauplius eye is still distinguishable as a bilobed structure in the middle line anterior to the labrum. On either side lie the larger, pigmented, cypris eyes, behind which and slightly nearer the middle line arise the long filamentous processes. The latter reach slightly beyond the proximal end of the third segment of the first antenna.

The labrum is longer than broad. The median portion of the tip is rounded and bears a fringe of setæ. The lateral angles of the tip are rounded and bear small tufts of setæ.

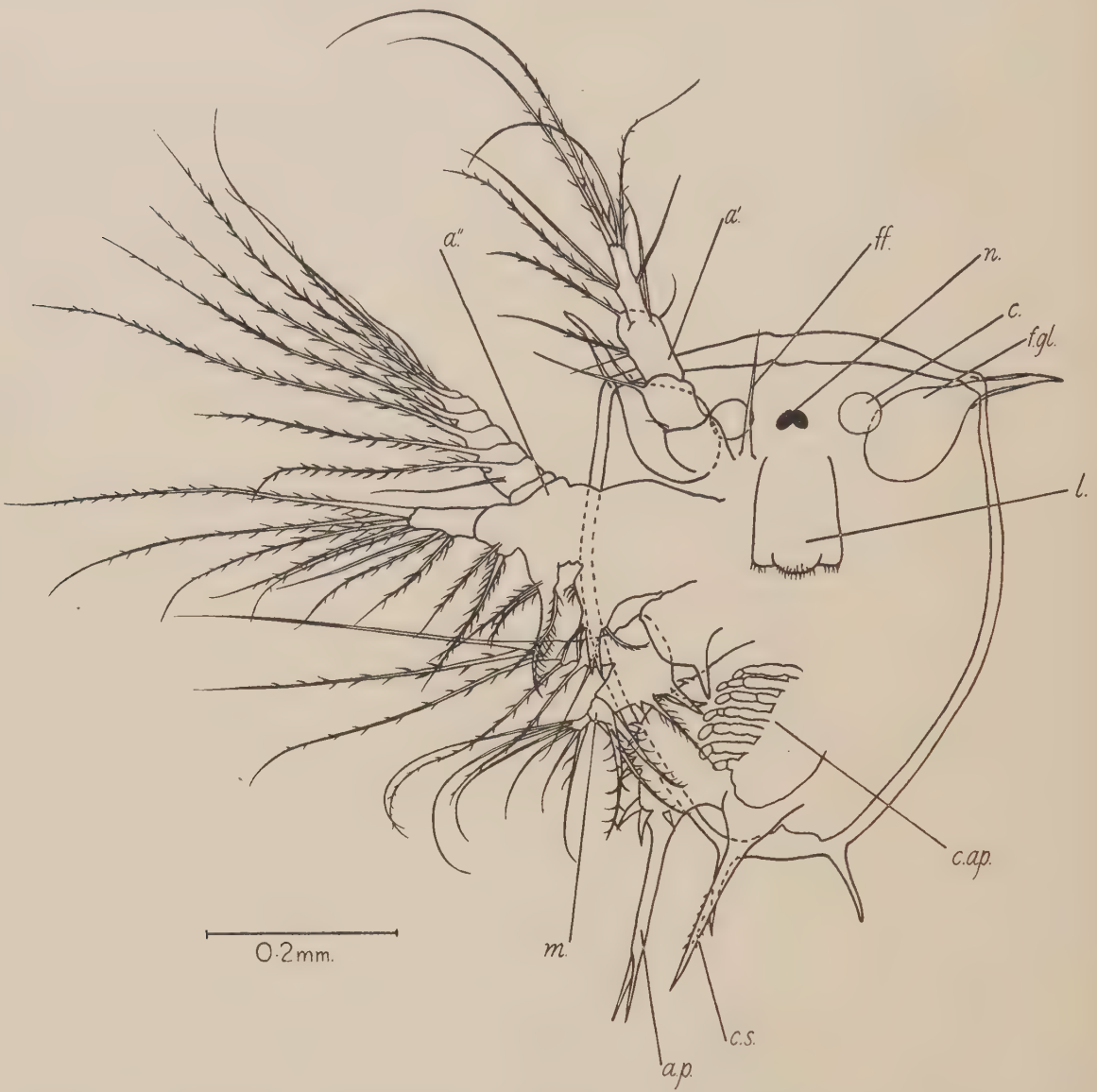
The first antenna is four-segmented. Segments 1 and 2 are roughly as broad as long. Segment 3 is twice as long as broad. Segment 4 is very much narrower, and nearly four times as long as broad. Segment 1 bears one very small setule on the posterior border. Segment 2 bears a single fairly long seta on the same side. Segment 3 has a pair of setæ, one very much longer than the other, on the anterior border: on the posterior border it bears one seta distally and a pair in the middle of its length. This last pair also are of unequal length. Segment 4 bears one seta at the middle of the anterior edge and a rather larger pair at the same level on the posterior edge. Terminally there are four setæ of unequal length.

The second antenna has a seven-segmented exopodite and a two-segmented endopodite. There are no setæ on the anterior border of the exopodite. This ramus has a single naked terminal seta and nine on the posterior border. All except the proximal of these are plumose. The proximal seta is only about half the length of the others. The endopodite, likewise, bears no setæ on the anterior border. There are five large setæ on the tip and three on the side of the second segment. The lower segment bears a pair of setæ. On the basal part of the appendage is a group of four setæ, one of which is very stout. All these setæ are plumose. The gnathobase of the second antenna has a bifid spinose tip and bears two tufts of setæ on its distal border. There is a single plumose seta on the proximal border.

The mandible consists of two large basal segments and small exopodite and endopodite of three and two segments respectively. There are no setæ on the anterior edge of either ramus. The exopodite bears a single terminal seta without setules. Four large plumose setæ and one small naked seta lie along the posterior border. The endopodite bears a terminal tuft of four naked setæ and close to them, on the posterior margin, a shorter pair, one of which bears a few setules. The first joint of the endopodite bears three stout setæ with strong setules. The first basal joint bears the straight spine-like gnathobase. The second basal segment bears two spine-like processes and a pair of slender plumose setæ.

Remarks.—This nauplius resembles very closely that described by Hansen (1899, p. 22) as Nauplius β, two specimens of which were obtained by the "Plankton-Expedition" from St. George's Harbour, Bermuda. The specific identity of Nauplius β has not been determined. The appendages of this nauplius are not figured by Hansen, so that it is

only possible to compare the form and spination of the carapace and abdominal process with the corresponding structures in the present specimens. The spination of the abdominal process is the same in both species. The carapace of the present specimens is considerably broader. Without knowing the structure of the appendages it is not possible to identify the two with certainty, and I shall not consider Hansen's species further.



Text-fig. 4.—Nauplius I. *a'*, antenna I. *a''*, antenna II. *a.p.*, abdominal process. *c.*, cypris eye. *c.ap.*, appendages of cypris. *c.s.*, caudal spine. *f.f.*, frontal filaments. *f.gl.*, glands of fronto-lateral horns. *l.*, labrum. *m.*, mandible. *n.*, nauplius eye.

Nauplius I likewise shows considerable affinity with the seventh and eighth naupliar stages of *Balanus crenatus* Bruguière, as figured by Herz (1933, p. 437). The chief differences from this species are the setation of the labrum and of the appendages. *B. crenatus* has numerous setæ on the median portion of the labrum and more on the lateral parts. As described above, setæ occur in both positions on Nauplius I, but are fewer in number than shown by Herz for *B. crenatus*.

Small differences occur in the setation of all the appendages. The first antenna is very similar to that of *B. crenatus*, but a small setule is present on the first segment and another on Segment 3, which are not shown by Herz. The rest of this appendage agrees with Herz's figure. According to this author the setæ on the first antenna of the eighth stage nauplius, that in which the cypris eyes appear, are reduced in length and without setules. Some of the setæ present in the seventh stage are lost in the eighth. In the present specimens, which are apparently in the last naupliar stage as they possess cypris eyes, setæ are present on all segments, the terminal ones are long and all the long ones are plumose.

The second antenna bears only ten setæ on the exopodite, as against twelve in *B. crenatus*. The endopodite bears fourteen setæ and a gnathobase. Herz's figure (eighth stage) shows only twelve setæ and a gnathobase on this part of the appendage. In *B. crenatus* the gnathobase is not bifid, terminating in two strong spines, but simply bears a tuft of stout setæ.

The mandible has the same number of setæ on the exopodite in both species. There are, however, thirteen setæ on the endopodite as compared with twelve in *B. crenatus*. The gnathobase is a spine in both species. The two setæ immediately distal to the gnathobase are without setules in Nauplius I. From Herz's figure of the eighth stage nauplius of *B. crenatus*, they seem to bear setules.

These differences of detail seem to be sufficient to exclude the nauplii under discussion from *Balanus crenatus*. This species has not so far been recorded from the Indian Ocean, though it is known from the Western Pacific as well as from the Atlantic. It is probable that Nauplius I belongs to a species of *Balanus* nearly related to, but not specifically identical with, *B. crenatus*. It appears, likewise, to be near to Hansen's Nauplius β.

The setation formulæ for the new nauplius and for *B. crenatus* are given below in the manner proposed by Bassindale (1936, p. 67). The formulæ for the appendages of *B. crenatus* are taken from Bassindale (1936, p. 71, table iv), who derived them from the figures given by Herz (1933, p. 437, pl. ii). The figures for *B. crenatus* are for the eighth naupliar stage unless otherwise stated.

Appendage.	*B. crenatus.*	Nauplius I.
Antenna I: .	. 1.1.**4**.2.1.2.1 (7th stage) but 1.**5**.1 (8th stage)	. 2.1.**4**.2.1.2.1.1
Antenna II:		
exopodite	. 0.**4**.8	. 0.**1**.9
endopodite	. 0.**4**.3.2.3.G.	. 0.**5**.3.2.4.G.
Mandible		
exopodite	. 0.**1**.5	. 0.**1**.5
endopodite	. 0.**4**.2.3.3.G.	. 0.**4**.2.3.2.2.G.

Nauplius II (Text-fig. 5).

Occurrence.—Sta. 172, Central Arabian Sea, 400–0 metres; 2 metanauplii.

Description.—The carapace is shield-shaped with numerous peripheral spines, of which three lateral pairs and a posterior pair are rather larger than the rest. Anteriorly there are two pairs of prominent spines between the fronto-lateral horns. The dorsal

side, except for a narrow peripheral region, is covered with very small denticles (Text-fig. 5 B). There is a long dorsal spine, broken in both specimens, but at least twice the length of the carapace. The spine is covered with spinules. The dimensions of the carapace are :

Length (excluding spines)	1120μ
Greatest breadth	855μ

There is the usual large number of peripheral glands on the carapace, opening on the spines. The fronto-lateral horns are directed slightly forwards in one specimen and at right-angles to the antero-posterior axis in the other. They terminate in two rami almost as long as the basal part of the horn. The rami bear terminal tufts of setæ, some of which appear to be plumose.

The nauplius eye has disappeared in both specimens. Paired cypris eyes are just distinguishable in one specimen (Text-fig. 5 A). In the other—that in which the fronto-lateral horns are laterally directed—they are larger, wider apart and darkly pigmented.

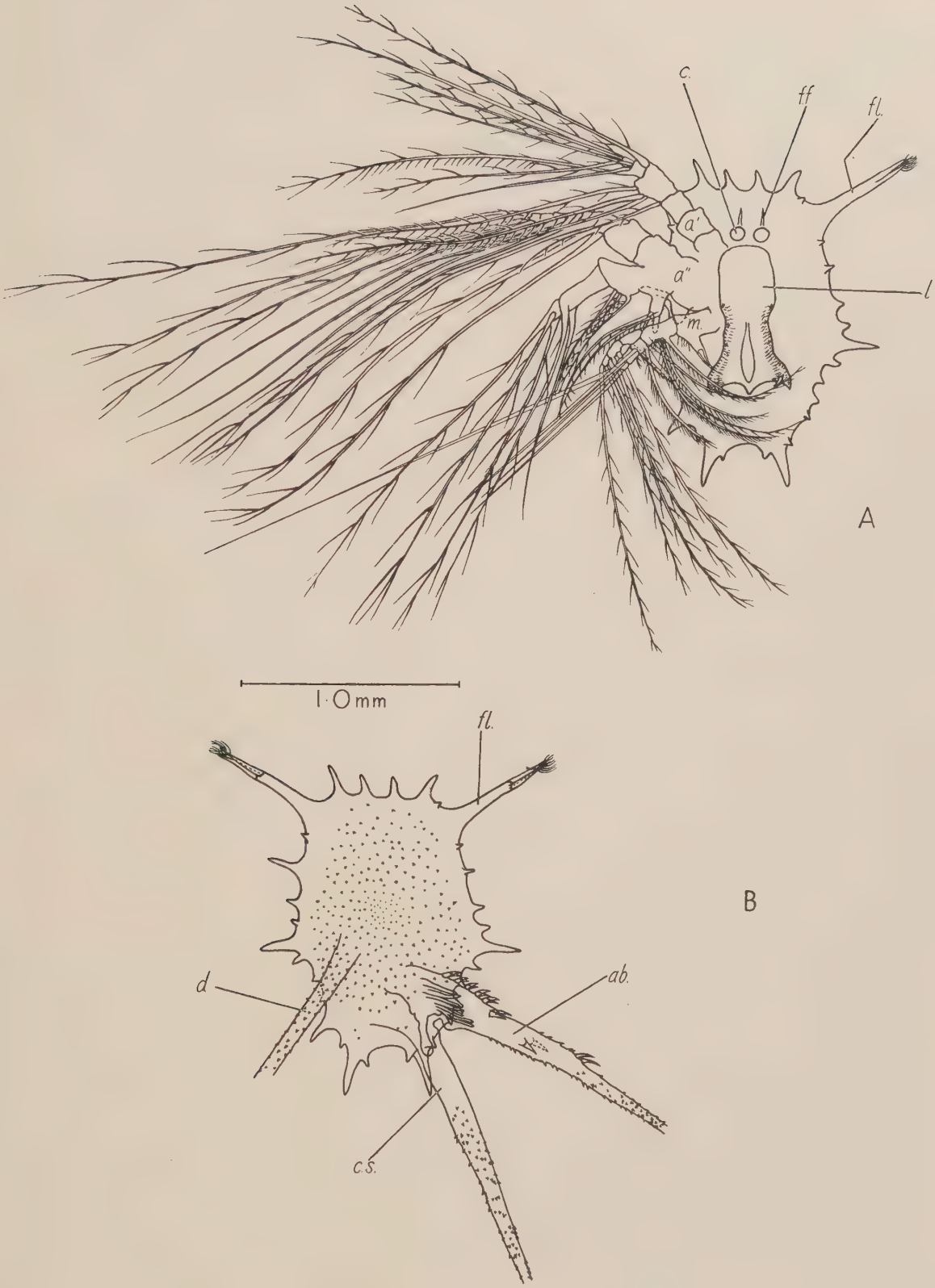
The frontal filaments are short and do not reach to the anterior border of the carapace.

The labrum is very similar to that of *Nauplius hastatus* and *N. eques* (Chun, 1895, pl. v). At the tip it bears paired anterior and lateral teeth and a median posterior tooth. Three pairs of small teeth lie on the sides of the labrum in its narrowest part. The distal two-thirds of the labrum bears several rows of short setæ on either side. These setæ are directed inwards towards the middle line of the labrum.

The caudal spine and abdominal process are broken in both specimens. The caudal spine appears to have been at least three times the length of the carapace. The abdominal process was probably four to four and one-half times the length of the carapace. The remaining portion is rather more than three times the carapace length. Both processes are armed with numerous small spines. In addition the abdominal process bears six pairs of large spines ventrally at its base. A little further along a pair of large lateral spines occur and a little distance further a ventral pair of large spines. The rudiments of the cypris appendages are visible in the region of the six pairs of spines.

The three pairs of appendages bear very long setæ. The first antenna is six-segmented. The first and second segments bear no setæ. Segment 3 bears a single short seta with no setules on its posterior border. Segment 4 bears a long plumose seta on its anterior border and three on its posterior : two of these latter are plumose, but the third is shorter and without setules. Segment 5 bears two unequal setæ on the posterior side. The longer of the two only has setules. There is a third, plumose seta on the ventral side of the segment. Segment 6 bears three plumose setæ, of which one is slightly longer than the others.

The second antenna consists of a two-segmented basal part bearing an exopodite and endopodite. Each segment of the basal part bears a process on the inner side. That on the basal segment is a simple lobe without setæ or spines, while that on the second basal segment is broader at the end and bears numerous fine setæ (not shown in Text-fig. 5 A) and three stout setæ, one of which is much shorter than the others. These three setæ are all plumose. The endopodite is three-segmented. The first segment is slightly longer than broad and bears three short plumose setæ. The second segment is about two-and-a-half times as long as broad and bears two unequal setæ, the longer of which alone is feathered. The setules on this segment are far apart and much longer than those



Text-fig. 5.—Nauplius II. A, Ventral view, showing labrum and appendages. B, Dorsal view of carapace showing dorsal and caudal spines and the abdominal process. *a'*, first antenna. *a''*, second antenna. *ab.*, abdominal process. *c.*, cypris eye. *c.s.*, caudal spine. *d.*, dorsal spine. *f.f.*, frontal filament. *fl.*, fronto-lateral horn. *l.*, labrum. *m.*, mandible.

on the previous segment. The third segment bears a terminal and a lateral pair of setæ, all with long setules.

The exopodite of the second antenna is 7-segmented. None of the segments bear setæ on the anterior border. The first segment bears no setæ. The second has two long setæ on the posterior border. Segments 3 to 6 each bear one seta. The setæ on segments 2 to 4 are plumose like those on the endopodite. Segment 7 bears one seta on the posterior border and three terminally, of which the most anterior is the largest. The three terminal setæ bear long setules. The setæ on segments 5 and 6 and the posterior one on segment 7 bear no setules. The long setæ of the exopodite are from one-and-one-half times to twice the length of the antenna. The longest setæ on the endopodite are rather shorter.

The mandible has a two-jointed basis and three segments in each of the rami. The first basal segment bears a conical biting process on the posterior border. On the distal border of this process is a patch of small setæ. This process contains a toothed plate, apparently the mandible of the adult barnacle. The second segment bears three long, recurved, plumose setæ on its posterior border.

The mandibular exopodite bears two setæ on segments 1 and 2 and three on the terminal segment. The setæ on segment 1 are curved towards the base of the limb like those on the second basal segment. The endopodite bears three setæ on the first segment, two on the posterior border and one on the side. Of the posterior pair one is very short and straight, and the other is about three times as long and curved towards the base of the appendage. Both bear setules. The third seta is simple and directed outwards along the limb-axis. Segment 2 bears one seta similar in form and position to that on the side of segment 1. The terminal segment bears two unequal, simple setæ, the longer of which is terminal and is very long and stout.

The setation formula, in the form proposed by Bassindale, is thus :

Antenna I	1.1.**3**.2.3.1
Antenna II :	
exopodite	0.**1**.2.2.3
endopodite	0.**3**.5.2
Mandible :	
exopodite	0.**1**.2.2.2
endopodite	0.**1**.1.1.3

Remarks.—Nauplius II shows affinities with a number of the larger nauplii described by various authors as follows :

"*Archizoea gigas*" Dohrn.
Nauplius of *Lepas fascicularis* Willemoës-Suhm.
Nauplius eques, *N. hastatus*, *N. loricatus* } Chun.
N. caudatus, *N. denticulatus*, *N. echinatus* } Gruvel, 1910.
N. longicaudatus Gruvel, 1920.

The present species and the nine listed above all have a number of characters in common, the most prominent of which are: the peripheral spination of the carapace; the long spinose caudal spine and abdominal process; the small denticles on the dorsal side of the carapace; and the six pairs of strong spines on the base of the abdominal process. The relative lengths of the caudal spine and abdominal process vary from species to species, as does also the length of each in terms of the length of the carapace.

The size of all these nauplii is considerable. They vary in length from 0·9 mm. to 1·5 mm., while the caudal spine and abdominal process may be from three to six times this length. The new specimens are thus of about average size for this type of nauplius.

The degree of development of the dorsal spine is variable. In *N. hastatus* Chun it is absent. In *N. loricatus* Chun and "*Archizoea gigas*" Dohrn it is short, less than the length of the carapace. The present specimens agree with the remaining six, viz.,

Lepas fascicularis nauplius,	*Nauplius denticulatus*,
Nauplius eques,	*N. echinatus*,
N. caudatus,	*N. longicaudatus*,

in having a long dorsal spine. Of these six species, *N. denticulatus* and *N. longicaudatus* are distinguished by the presence of a row of small denticles on the anterior margin of the carapace. These are not present in any of the other species listed above. *N. longicaudatus*, moreover, has the dorsal spinules extending almost to the tips of the peripheral spines. *Lepas fascicularis* nauplius and *N. caudatus* have each a distinctive outline. The peripheral spines of *L. fascicularis* are small. In *N. caudatus* the large posterior spines are denticulate. The general shape and spination of the carapace of Nauplius II is closest to that seen in *N. eques* and *N. echinatus*.

N. eques can be distinguished on the structure of the mandible, which bears six large curved spines on its posterior border, whereas the mandible of Nauplius II has only one nearly straight spine in this position. *N. echinatus* differs considerably from Nauplius II in the shape of the labrum. The form of the labrum in Nauplius II is nearest to that found in *N. hastatus* and *N. eques*.

The form of the ends of the fronto-lateral horns is distinctive. In Nauplius II these end in two rami with terminal tufts of setæ (Text-fig. 5 A). Of the nine species of nauplius listed above similar horns occur only in "*Archizoea gigas*" and *N. loricatus*, which have already been separated from the rest on the shortness of the dorsal spine. In *N. loricatus*, moreover, there is a third slender ramus on the fronto-lateral horn which Gruvel terms the "epipodite". This is not present in the new nauplius.

The present specimens thus possess characters in common with several species of nauplii, but differ from them all in one or more characters. I have thus thought it desirable to separate the specimens from any of the described species as a new form which I propose to designate as Nauplius II, as to give it a specific name will in all probability only add to the synonymy of a well-established species when the adult of this nauplius is determined.

Nauplius II can be distinguished by the following combination of characters: the long dorsal spine, the two setose rami on the fronto-lateral horns, the shape of the labrum, and the presence of a single spine on the protopodite of the mandible.

Nauplius II appears to be most nearly allied to *N. eques* Chun, a single example of which was obtained off Madeira (Chun, 1895, p. 81).

Cypris I (Text-fig. 6).

Occurrence.—Sta. 58, South Arabian Coast, surface ; 1 specimen.

Description.—The larva is dark brown in colour, like Nauplius I. Little of the internal organization, except the outline of the adult body, can be made out. The cirri project slightly from the bivalve shell and the attaching antennæ are directed forwards. The latter have a disc-like attaching surface and a small terminal segment bearing a few short setæ. There appears to be no sensory process.

Text-fig. 6.—Cypris I, probably of the same species as Nauplius I.

Remarks.—It is possible that this cypris belongs to the same Balanid species as Nauplius I described above (p. 390). The larva is of the same size as this nauplius and similarly coloured. Furthermore, all the specimens of Nauplius I were in the last naupliar stage and show cypris eyes, and no other nauplii were obtained in this plankton haul.

LIST OF REFERENCES.

Annandale, N. 1909. An Account of the Indian Cirripedia Pedunculata. Pt. I. Family Lepadidæ s. str. Mem. Indian. Mus. II, pp. 61–138, pls. vi, vii.

—— 1914. New and Interesting Pedunculate Cirripedes from Indian Seas. Rec. Indian Mus. X, pp. 273–280, pls. xxxiii, xxxiv.

Aurivillius, C. W. S. 1894. Studien über Cirripedien. K. Svenska Vetensk. Akad. Handl. XXVI, no. 7, pp. 1–89, pls. i–ix.

Bassindale, R. 1936. The Developmental Stages of Three English Barnacles, *Balanus balanoides* (Linn.), *Chthamalus stellatus* (Poli) and *Verruca strœmia* (O. F. Muller). Proc. Zool. Soc. London, 1936, pp. 57–74, text-figs. 1–9.

Broch, Hj. 1922. Papers from Dr. Mortensen's Pacific Expedition 1914–16. X. Studies on Pacific Cirripeds. Vidensk. Medd. naturh. foren. Kjøbenhavn, LXXIII, pp. 215–358, text-figs. 1–77.

Chun, C. 1895. Atlantis. Biologische Studien über pelagische Organismen. III. Die Nauplien der Lepaden. Zoologica, Stuttgart, Hft. XIX, lf. 2, pp. 77–106, pls. v, vi, 1 text-fig.

Darwin, C. 1851. Monograph on the Sub-class Cirripedia : I. Lepadidæ. Ray Society, London, pp. xi, 400, 11 pls.

—— 1854. Monograph on the Sub-class Cirripedia : II. The Balanidæ ; the Verrucidæ. Ray Society, London, pp. viii, 684, 31 pls.

Dohrn, A. 1870. Untersuchungen über Bau und Entwicklung der Arthropoda, IX. Eine neue Nauplius-Form (Archizoea gigas). Z. wiss. Zool., pp. 597–606, pls. xxviii, xxix.

Groom, T. T. 1894. On the Early Development of Cirripedia. Philos. Trans. pp. 119–232, pls. xiv–xxviii, text-figs. 1–3.

Gruvel, A. 1910. Die Cirripedien der Deutschen Südpolarexpedition. Deutsche Südpolar-Exped. 1901–03, Bd. XI, Zool. 3, pp. 193–230, pls. xxiii–xxvi.

—— 1920. Cirrhipèdes provenant des Compagnes scientifiques de S.A.S. le Prince de Monaco 1885–1913. Résult. Camp. sci. Monaco, LIII, pp. 1–88, pls. i–vii.

Hansen, H. J. 1899. Die Cladoceren und Cirripedien der Plankton-Expedition. Ergebn. der Plankton-Exped. d. Humboldt-Stiftung, Bd. II, G.d., pp. 1–58, pls. i–iv.

Herz, L. E. 1933. The Morphology of the Later Stages of *Balanus crenatus* Bruguière. Biol. Bull. Wood's Hole, LXIV, pp. 432–442, pls. i–iii in text.

Hiro, F. 1937. Studies on Cirripedian Fauna of Japan. II. Cirripeds found in the Vicinity of the Seto Marine Biological Laboratory. Mem. Coll. Sci. Kyoto, Japan, XIIb, pp. 385–478, text-figs. 1–43.

Hoek, P. P. C. 1907. The Cirripedia Pedunculata. Siboga-Exped. Monog. XXXI*a*, pp. i–xxv, 1–128, pls. i–x.

—— 1913. The Cirripedia Sessilia. Siboga-Exped. Monog. XXXI*b*, pp. 129–275, pls. xi–xxvi.

Jackson, H. G. 1913. Eupagurus. L.M.B.C. Memoir XXI, pp. i–viii, 1–79, pls. i–vi, 2 text-figs.

Nilsson-Cantell, C. A. 1921. Cirripedien-studien. Zool. Bidrag Uppsala, VII, pp. 75–395, pls. i–iii, text-figs. 1–89.

—— 1927. Some Barnacles in the British Museum (Nat. Hist.). Proc. Zool. Soc. London, 1927, pt. 2, pp. 743–790, pl. i, text-figs. 1–19.

—— 1929. Cirripedien des Genus Verruca der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia", 1898–1899. Zool. Jahrb. (Syst.) LVIII, pp. 459–480, text-figs. 1–7.

—— 1934. Indomalayan Cirripeds in the Raffles Museum. Bull. Raffles Mus. Singapore, no. 9, pp. 42–73, pl. v, text-figs. 1–7.

Pilsbry, H. A. 1907. The Barnacles (Cirripedia) Contained in the Collections of the American Museum of Nat. Hist. Bull. U.S. Nat. Mus. LX, pp. 1–122, pls. i–xi, text-figs. 1–36.

—— 1912. Diagnoses of New Barnacles from the Philippine Archipelago and China Sea. Proc. U.S. Nat. Mus. XLII, pp. 291–294.

—— 1916. The Sessile Barnacles (Cirripedia) Contained in the Collections of the U.S. National Museum, including a Monograph of the American Species. Bull. U.S. Nat. Mus. XCIII, pp. i–xi, 1–366, pls. i–lxxvi.

Stubbings, H. G. 1936. Cirripedia. "John Murray" Exped. Sci. Repts. IV, 1, pp. 1–70, text-figs. 1–30.

Willemoës-Suhm, R. von. 1877. On the Development of *Lepas fascicularis* and the "Archizoea" of Cirripedia. Philos. Trans. CLXVI, pp. 131–154, pls. x–xv.